Fig. 1

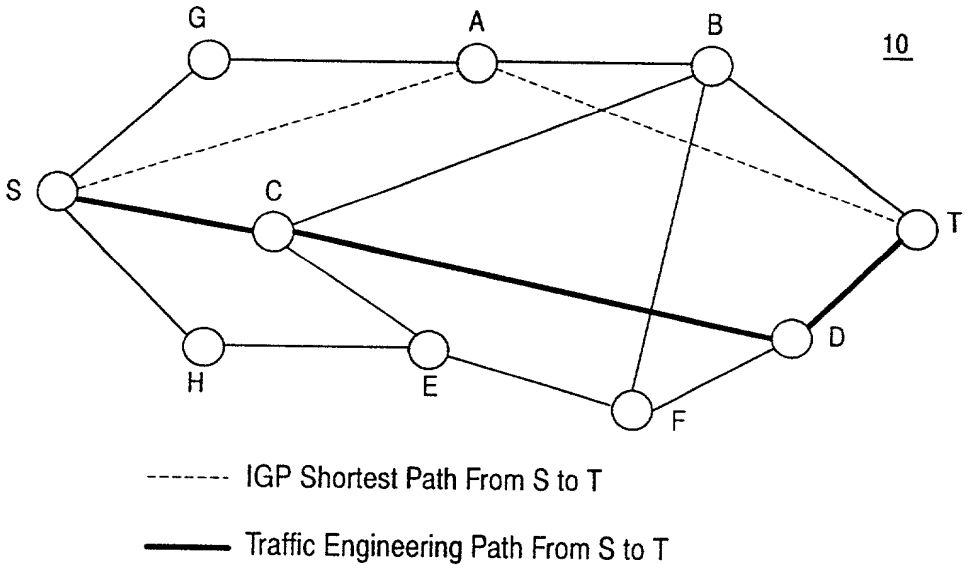

G
A
B
10
S
C
T
D
H
E
F
------- IGP Shortest Path From S to T
Traffic Engineering Path From S to T

Fig. 4

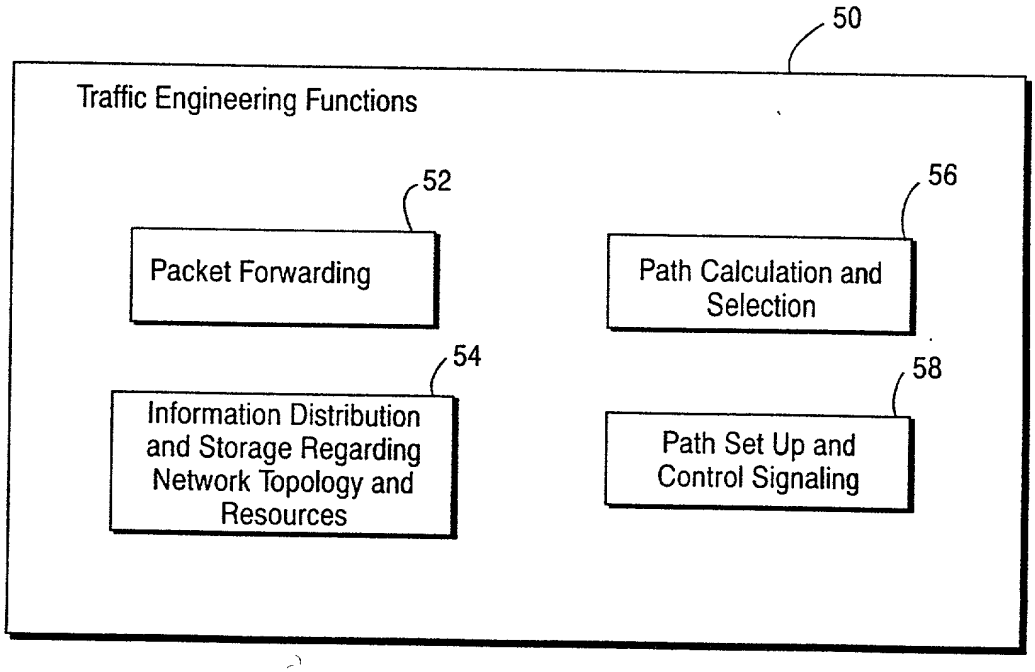

50
Traffic Engineering Functions
52
Packet Forwarding
56
Path Calculation and Selection
54
Information Distribution and Storage Regarding Network Topology and Resources
58
Path Set Up and Control Signaling

Fig. 2

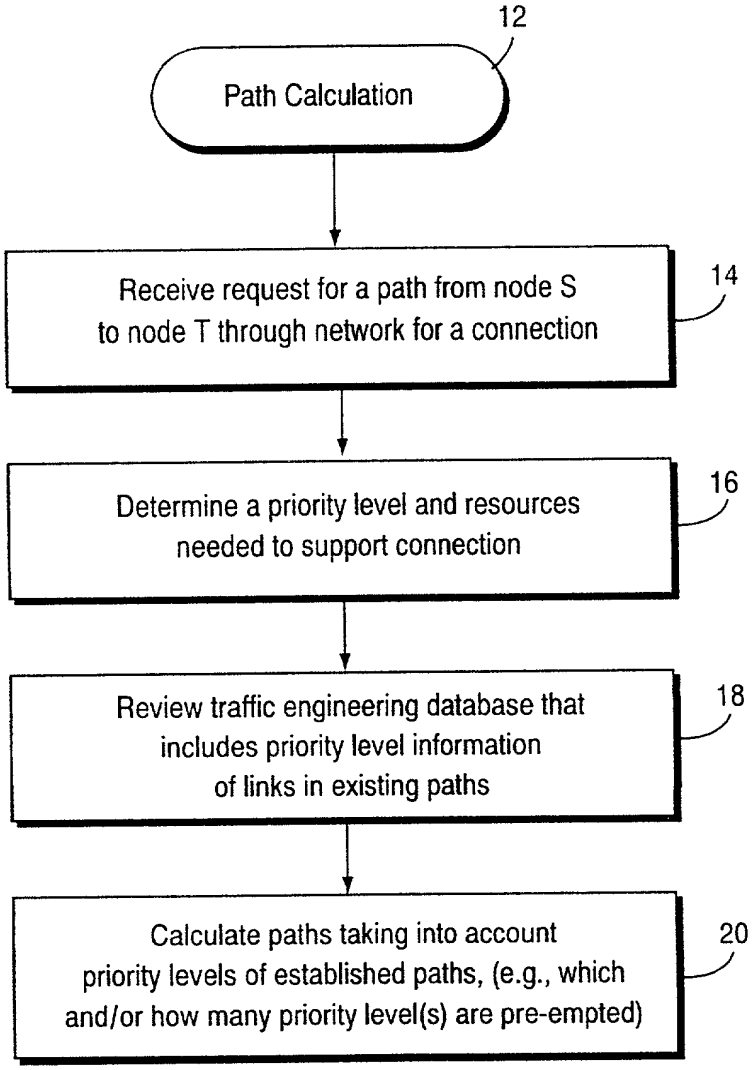

12
Path Calculation
Receive request for a path from node S to node T through network for a connection
14
Determine a priority level and resources needed to support connection
16
Review traffic engineering database that includes priority level information of links in existing paths
18
Calculate paths taking into account priority levels of established paths, (e.g., which and/or how many priority level(s) are pre-empted)
20

Fig. 3

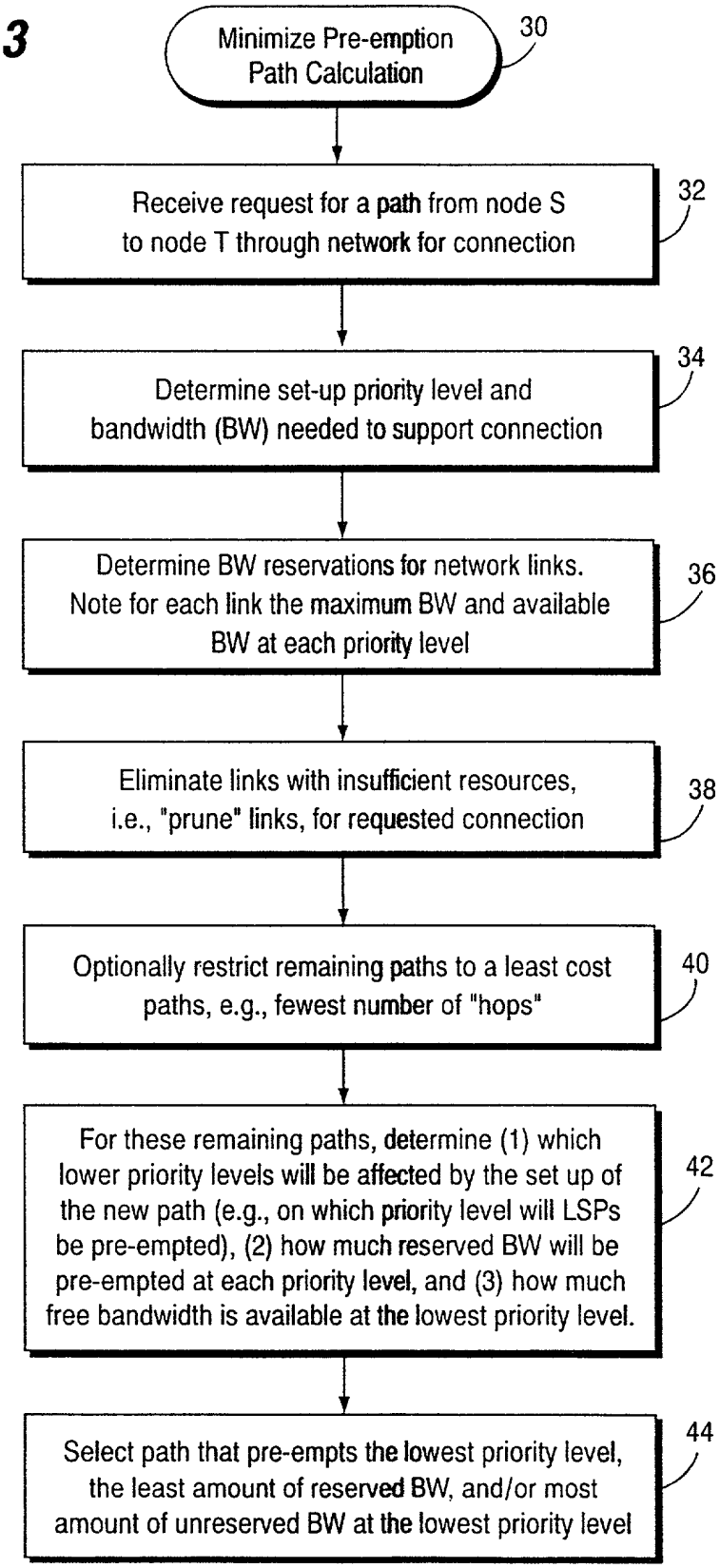

Minimize Pre-emption Path Calculation
30
Receive request for a path from node S to node T through network for connection
32
Determine set-up priority level and bandwidth (BW) needed to support connection
34
Determine BW reservations for network links. Note for each link the maximum BW and available BW at each priority level
36
Eliminate links with insufficient resources, i.e., "prune" links, for requested connection
38
Optionally restrict remaining paths to a least cost paths, e.g., fewest number of "hops"
40
For these remaining paths, determine (1) which lower priority levels will be affected by the set up of the new path (e.g., on which priority level will LSPs be pre-empted), (2) how much reserved BW will be pre-empted at each priority level, and (3) how much free bandwidth is available at the lowest priority level.
42
Select path that pre-empts the lowest priority level, the least amount of reserved BW, and/or most amount of unreserved BW at the lowest priority level
44

Fig. 5 MPLS Forwarding Table

Input	Input Label	Output	Output Label
2	17	3	12

Fig. 6

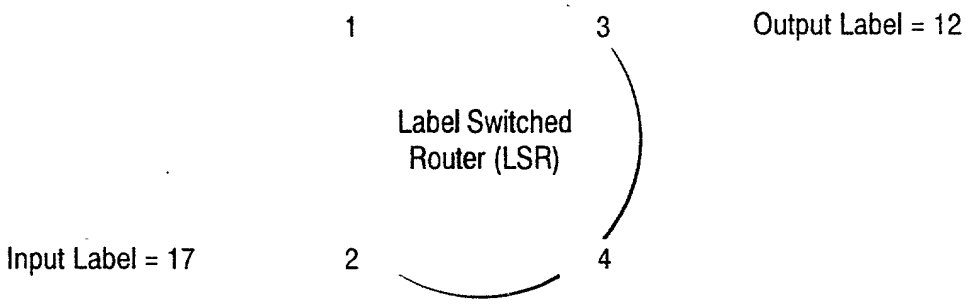


Fig. 7

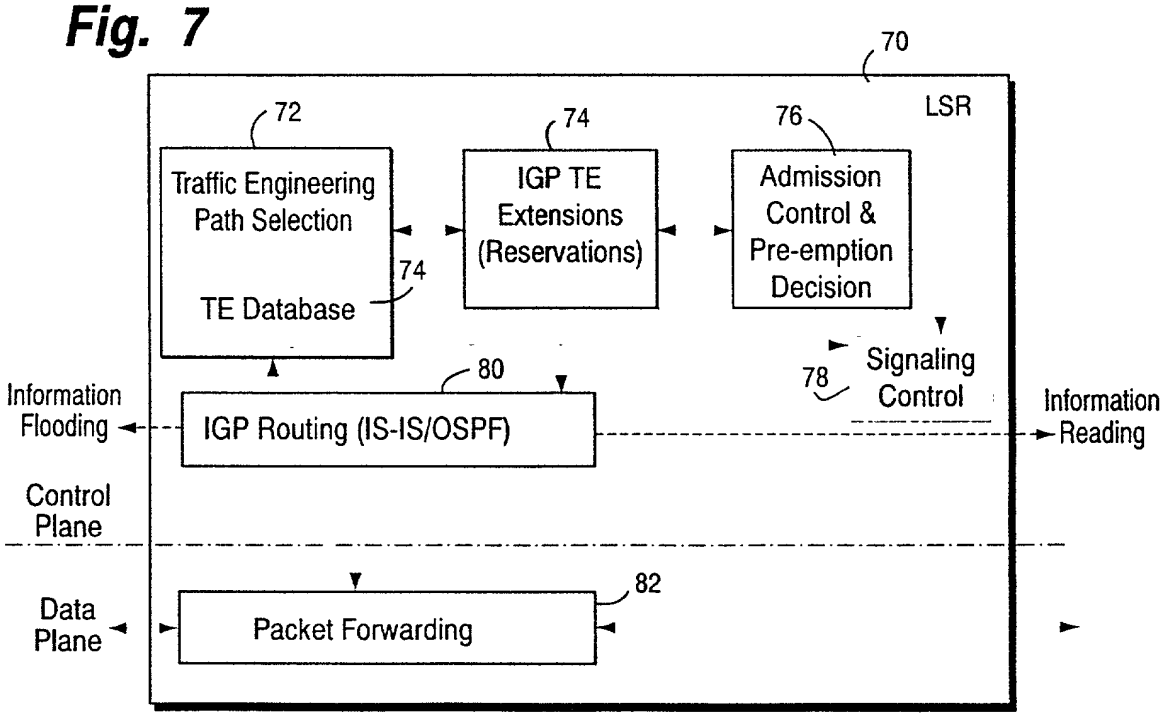
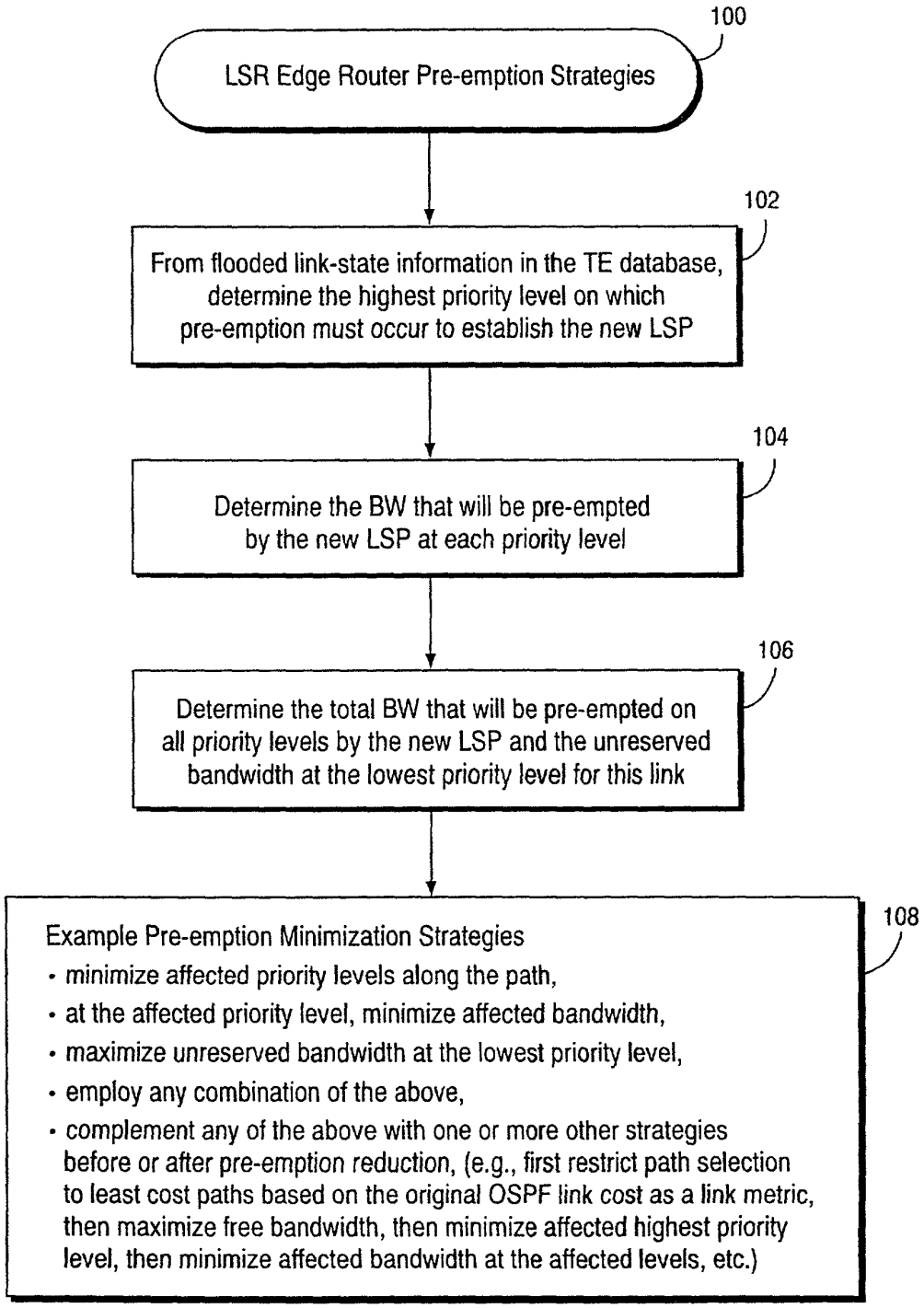


Fig. 8


100
LSR Edge Router Pre-emption Strategies
102
From flooded link-state information in the TE database, determine the highest priority level on which pre-emption must occur to establish the new LSP
104
Determine the BW that will be pre-empted by the new LSP at each priority level
106
Determine the total BW that will be pre-empted on all priority levels by the new LSP and the unreserved bandwidth at the lowest priority level for this link
108
Example Pre-emption Minimization Strategies
• minimize affected priority levels along the path,
• at the affected priority level, minimize affected bandwidth,
• maximize unreserved bandwidth at the lowest priority level,
• employ any combination of the above,
• complement any of the above with one or more other strategies before or after pre-emption reduction, (e.g., first restrict path selection to least cost paths based on the original OSPF link cost as a link metric, then maximize free bandwidth, then minimize affected highest priority level, then minimize affected bandwidth at the affected levels, etc.)